Thursday, January 11, 2018 Site Visit to NCRA Roadway
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The site visit was timed to catch a low tide (chart attached) and a few days after a storm event.

Slough/Marsh/Road Inundation – We explored extent and location of tidal channels in the tidal marsh located inland of the road to try and assess frequency and source of tidal inundation or groundwater flow. There is a main tidal channel that is 3 – 4 feet deep and extends deep into the marsh, as well as smaller tidal channels, all of which appear to receive regular wetting based on their appearance, depth, shape, scoured nature and health of adjacent tidal marsh vegetation. Inundation may occur via the tides, the culvert and/or through groundwater flow due to a high water table. Inundation may occur via overtopping at tides higher than the elevation of the road. More intensive observation or assessment of the tidal cycle is needed to understand the hydrological characteristics of the site.

It appears that the headwall was not secured sufficiently to the support rails by bolts, which enabled the flood waters to dislodge two of the timbers and carry them inland. It appears that the road may have subsequently washed out when the flood waters receded, carrying away a significant amount of debris and depositing it primarily within the first 150 – 200 feet of the slough northeast of the road, where staff observed mounds of soil and rocks that appear to match the type of rock used as fill and ground cover on the road. Based on these observations, it seems clear that the debris in the slough originates from the road. (There was some thought as to whether the rock could be that of the ballast used as base for the railroad tracks, but that idea was ruled out based on the difference in morphology between the railroad base and debris in the slough, which more closely matched that of the gravel used as road cover. Additionally, no base debris was observed in the marsh immediately adjacent to either side of the tracks which would indicate a normal pattern of deposition of the railroad base into the marsh and slough.)

The indications of scouring and erosion along the banks of the slough suggest that when the road was washed out by the retreating flood/storm waters, it must have been a fairly rapid and violent occurrence that dragged the road debris along the walls of the slough, etching away at them and cutting deep furrows into the bank. Beyond the debris field, where the slough crosses under the railroad track, within about 90 to 120 feet of the bank of the Petaluma River, the bed of the slough is choked with large mud deposits. It seems plausible that a significant portion of the mud deposits originated from the road, but further testing should be required to surmise its origin.

Condition of Culvert - There is pooling of water on both sides of the culvert. The culvert may be located below the current elevation of the slough bed. The culvert may be partially blocked by debris inside the culvert. Rafael suggested that the culvert may be at least partially blocked, given the high concentrations of muddy and coarse sediments and rocks in the system. We suspect that it is too small to accommodate the extent of flow that occurs during the tidal exchanges and that the size of the culvert may contribute to the wash outs since the water must overtop the road if it cannot pass under it. Dave Anderson's report states that lowest

parts of the road surface are located at the southwest edge of fill (Point 19 on his 8/3/2016 survey map.)

Health of Inland Marsh (West of the Road) - We observed that the same brackish salt marsh species appear along the edge of the Petaluma River as in the marsh located inland of the road. The presence of the road in its current condition does not appear to be having an obvious adverse impact on the health of the marsh on the inland side of the road, but a survey of the site conducted by a qualified professional is needed to assess any past, present or potential impacts to the marsh. The water on landward side of road appeared static (but so did the pooled water just bay-ward of road, behind debris pile, that was slowly draining into channel

Two Headwall Pieces – We discovered two timbers tied together in the marsh that we suspect are the two missing timbers from the headwall that NCRA has stated it removed from the site after they were displaced by the storm. The fact that they were displaced approximately 100 feet inland of the road where they were installed indicates that the volume and velocity of water was sufficient to float them that entire distance, perhaps on an incoming tide while the area was flooded in winter/spring 2016/17. Each timber measures 14'7" long by 1'4.5" high by 8" wide, approximately 444 pounds each. (Density of pine--one of the least expensive types of lumber--is approx. 530 kg/m^3.)

Elevation of Culvert – We attempted to make crude measurements of the depth of the pool located at the mouth of the culvert. Our measuring stick went 1' 7" below water level. Walt probed for the mouth of the culvert with the intention of assessing whether it was clogged with debris but was unable to locate it because the wood prod was floating. He was able to probe below the bottom of the lowest timber edge.

Potential Stabilization Ideas – Pave surface with slotted drains, articulated concrete mats or permeable pavers. Improve drainage. Construct bridge. Clear culvert so it flows freely (rotorooter). Expand/replace culvert with larger opening. Use wingwalls on sides of headwall north and south. Build a fixed/permanent channel/cavity across the road to route overtopping waters away from roadway, etc. Some of these ideas may require permit authorization.

Actions – Remove debris from slough channel, stabilize road, restore hydrology, bolt boards to tie beams (see adjacent treatment on RR track embankment), *depth of RR drilled through and bolted together, mix gravel with cement, use anchored timber boards as road surface.*